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CONTAMINATION OF THE CHANNEL CATFISH (*ICTALURUS PUNCTATUS*) BY ORGANOCHLORINE PESTICIDES AND POLYCHLORINATED BIPHENYLS IN THE MISSOURI RIVER

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Channel catfish (*Ictalurus punctatus*) were collected at ten locations from the Missouri River adjoining Nebraska. Fillet samples were found to be contaminated with DDT, PCB, dieldrin, heptachlor, trifluralin, and chlordane. At one location, near Bellevue, concentrations of chlordane exceeded Federal Food and Drug Administration action levels. This indicates channel catfish caught and consumed from the Bellevue area may pose a threat to human health. This study provides baseline information on the contamination of channel catfish in the Missouri River adjoining Nebraska.

† † †

The Missouri River is a fisheries resource for the states of Nebraska, Iowa, and Missouri. In 1985, commercial fishermen from these three states harvested more than 147,800 kg (327,000 pounds) of fish from the portion of the Missouri River bordering Nebraska (Zuerlein, 1988). Recreational fishing along the Missouri River has increased in recent years and is expected to continue increasing as commercial harvest is controlled, access is improved, and habitat is restored.

As human consumption of Missouri River fish expands, there is a growing concern over how safe these fish are to eat. The Missouri Department of Health issued consumption advisories on February 11, 1987, for fish harvested from the Missouri River between Kansas City and St. Louis. Although no advisories have been issued, fish collected from the Bellevue area of Nebraska from 1985 through 1987 have shown elevated levels of chlordane in their tissue (Nebraska Department of Environmental Control, 1988).

In 1988, the Nebraska Department of Environmental Control, Nebraska Game and Parks Commission, and United States Environmental Protection Agency Region VII, jointly collected and analyzed channel catfish (*Ictalurus punctatus*) from selected locations along the Missouri River. Fillet tissue samples were analyzed for organic contaminants. The objectives of the study were to measure the levels of contamination in channel catfish and to evaluate human health risks from eating these fish by comparing concentrations of contaminants

to Food and Drug Administration (FDA) action levels.

STUDY AREA

Channel catfish were collected from ten locations (Fig. 1) in the Missouri River along the eastern border of Nebraska (River Mile 497 to River Mile 866). Stream flow in this reach is regulated by the Fort Randall Dam. Discharges at Sioux City, Iowa were maintained in a range of 708 m^3/s to 990 m^3/s from April 1 to December 1 and from 170 m^3/s to 566 m^3/s during the period December 1 to April 1 (Slizeski et al., 1982). Major municipal and industrial dischargers to the study reach include Sioux City, Iowa; Omaha, Nebraska; Fort Calhoun and Cooper Nuclear Power Plants, Nebraska; Council Bluffs, Iowa; and Iowa Beef Processors Inc. at Dakota City, Nebraska.

MATERIALS AND METHODS

Channel catfish were selected because of their importance to recreational and commercial fishing, bottom-feeding habits, and high-lipid content (many contaminants are lipophilic compounds). Fish were collected using cheese-baited hoop nets and electrofishing gear. Three samples were collected from each sampling station. Each sample, except that from Station 7, comprised the fillets of 3 fish. At Station 7 one sample contained the fillets of two fish, and the other two samples contained the fillets of one fish each. The fish in the samples ranged in length from 270 mm to 520 mm and weighed from 175 g to 1,235 g.

SAMPLE PREPARATION AND ANALYSIS

Each sample was ground using a Hobart Model 32 meat grinder, blended by hand for several minutes, and ground a second time. (Disclaimer - Any mention of trade names within this report does not constitute endorsement by the U.S. Environmental Protection Agency). A 50-gram aliquot of the homogenized tissue was mixed with dry ice and 100 grams of sodium sulfate in a blender. The resultant mixture was wrapped in aluminum foil and the dry ice was allowed to sublime in a freezer, overnight. The tissue/salt mixture was placed in a glass chromatographic column containing 100 ml of methylene chloride. An additional 100 ml of methylene chloride were added to the column, allowed to stand for ten minutes, and eluted at a rate of 3 to 6 ml per minute. The resultant extract was concentrated to 1 ml using a Kuderma-Danish (K-D) apparatus. The concentrate was diluted with 25 ml of methylene

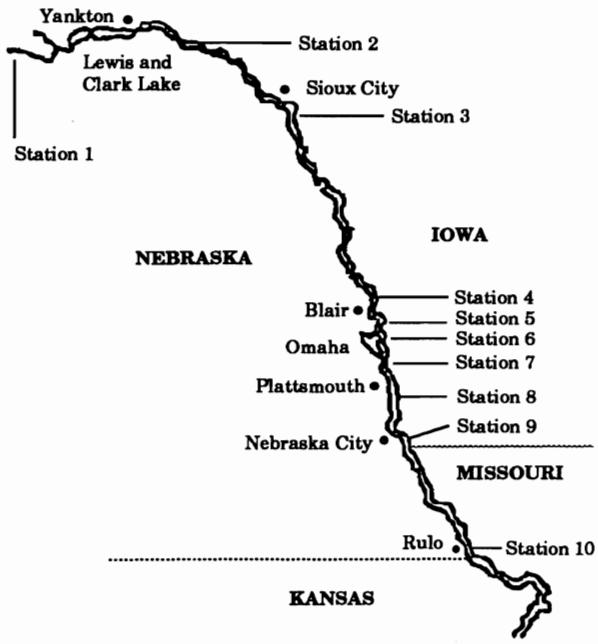

Figure 1. Study area of Missouri River with sampling stations. Station numbers, locations, and river miles (based on United States Geological Survey 7 1/2 minute topographic maps). Station 1: Lynch, Neb., river mile 866. 2: Sioux city, Iowa, river mile 739. 3: Dakota City, Neb., river mile 725. 4: Blair, Neb., river mile 641. 5: North Omaha, Neb., river mile 627. 6: Omaha, Neb., river mile 610. 7: Bellevue, Neb., river mile 596. 8: Plattsmouth, Neb., river mile 590. 9: Nebraska City, Neb., river mile 560. 10: Rulo, Neb., river mile 497.

chloride and 8 ml of this mixture was injected into an Analytical Biochemistry Laboratories, Inc. GPC (Gel Permeation Chromatography) Autoprep 1002A Unit to remove substances such as fats and oils. The extract was analyzed for organochlorine pesticides and polychlorinated biphenyls according to EPA method 608 (Federal Register, 1984).

DATA ANALYSIS

The Statistical Analysis System (SAS Institute, Inc., copyright 1984, 1986) was used for all statistical computations. Mean wet-weight concentrations for each station were compared using an Analysis-of-Covariance model. Differences of mean wet-weight concentrations between stations were examined using a least-squares-means (LSM) test. A significance level of $p \leq 0.05$ was used for all statistical tests.

Human health risks were evaluated by comparing wet-weight concentrations to the following Food and Drug Administrations Action Levels (FDA 1984).

CONTAMINANT	ACTION LEVEL
PCB	2.0 mg/kg
DDT	5.0 mg/kg
Chlordane	0.3 mg/kg
Aldrin/Dieldrin	0.3 mg/kg
Heptachlor	0.3 mg/kg

RESULTS

Contaminants detected at one or more sampling stations included DDT (or DDT metabolites), PCB, dieldrin, heptachlor (and metabolite), chlordane, and trifluralin. Mean wet-weight concentrations (mg/kg) and the highest wet-weight concentration (mg/kg) found at each sampling station are included in Tables I and II.

Mean lipid concentrations were significantly different between sampling stations ($p \leq 0.05$). The contaminants found in the fish samples tend to be lipophillic compounds and significant differences in lipid content could influence statistical comparisons using wet-weight concentrations; therefore, statistical tests were made using an analysis of covariance.

Concentrations of the contaminants DDT, chlordane, "total chlordane", cis-chlordane, trans-chlordane, cis-nonachlor and trifluralin were significantly different between sampling stations ($p \leq 0.05$). Arruda et al. (1987), have also shown a spatial difference in concentrations of chlordane in fish tissue for rivers in Kansas.

DDT—1,1'-(2,2,2-Trichloroethylidene)bis[4-chlorobenzene]

Schmitt et al. (1985), reported that, across the nation, concentrations of DDT declined significantly from 1976-77 to 1980-81; however, DDT is still consistently detected in fish tissue. Our sample results demonstrate the persistence of DDT. The DDT metabolite, p,p'-DDE was detected in at least one sample from each of the ten sampling stations (Table I). Mean concentrations of p,p' - DDE were not significantly different between stations. The nondegraded form of DDT, p,p'-DDT, was found at five of the sampling stations and tended to occur more frequently at and downstream of the Bellevue station. Concentrations of DDT were significantly different between stations. The LSM test found Station 7 to be different from the other stations. While DDT was regularly detected in fish tissue, the highest wet-weight concentration detected (0.046 mg/kg) was less than the FDA action level (5.0 mg/kg).

Dieldrin—3,4,5,6,9,9-Hexachloro-1a,2,2a,3,6,6a,7,7a,octahydro-2,7:3,6-dimethanonaphth[-2,3-b] oxirene

Dieldrin was detected at nine of the sampling stations (Table I); dieldrin was not detected at Station 1, which is located upstream of Gavins Point Dam. The highest mean wet-weight concentrations (0.06 mg/kg) of dieldrin occurred at Station 9, Nebraska City. The highest dieldrin wet-weight concentration found was 0.11 mg/kg which is less than the FDA action level (0.3 mg/kg).

Polychlorinated Biphenyls (PCB)

Both PCB 1254 and PCB 1260, were detected in channel catfish from the Missouri River (Table I). PCB 1254 was detected at 7 stations while PCB 1260 was found at only two stations. Mean concentrations of PCB were not significantly different between stations. The highest concentration (0.43 mg/kg) was collected from Station 10, Rulo. All concentrations of PCB were less than the FDA action level (2.0 mg/kg).

Heptachlor—1,4,5,6,7,8,8-Heptachlor-3a,4,7,7a-tetrahydro-4,7-methanoindene

Trace amounts of heptachlor were detected only at Station 8, Plattsmouth. However, heptachlor is usually found in tissue samples in the form of the metabolite heptachlor epoxide. Heptachlor epoxide was found at seven of the ten sampling stations and

Table I. Mean wet-weight concentration (mg/kg) and (highest concentration) (mg/kg) of contaminants detected in channel catfish (*Ictalurus punctatus*) from the Missouri River, 1988.

Station	DDT mg/kg	DDE mg/kg	DDD mg/kg	PCB-1254 mg/kg	PCB-1260 mg/kg	Dieldrin mg/kg	Hepta-chlor Epoxide mg/kg	Tri-fluralin mg/kg
1	ND	0.012 (0.016)	ND	0.054 (0.100)	ND	ND	ND	ND
2	0.0008 (0.0025)	0.0152 (0.0230)	ND	0.059 (0.150)	ND	0.003 (0.01)	ND	0.004 (0.0063)
3	ND	0.0072 (0.0098)	ND	ND	ND	0.004 (0.012)	ND	0.004 (0.011)
4	ND	0.016 (0.018)	ND	ND	ND	0.007 (0.020)	0.0011 (0.0033)	0.026 (0.038)
5	ND	0.028 (0.046)	ND	0.081 (0.170)	ND	0.037 (0.079)	0.004 (0.013)	0.031 (0.067)
6	ND	0.021 0.023)	ND	0.057 (0.110)	0.018 (0.053)	0.0187 (0.021)	0.002 (0.005)	0.017 (0.021)
7	0.012 (0.018)	0.033 (0.045)	0.012 (0.020)	0.035 (0.055)	ND	0.030 (0.035)	0.0050 (0.0061)	0.063 (0.074)
8	0.0030 (0.0049)	0.019 (0.025)	ND	ND	ND	0.019 (0.021)	0.0016 (0.0047)	0.022 (0.029)
9	0.0023 (0.0068)	0.028 (0.060)	ND	0.092 (0.100)	0.024 (0.073)	0.064 (0.110)	0.0059 (0.0072)	0.0413 (0.062)
10	0.003 (0.006)	0.019 (0.024)	ND	0.17 (0.43)	ND	0.028 (0.058)	0.0023 (0.0037)	0.025 (0.026)

ND - Not detected in any sample.

was not detected in any stations upstream from Station 4, Blair (Table I). Wet weight concentrations of heptachlor epoxide were quite low; 0.0072 mg/kg was the highest concentration found. Mean wet-weight concentrations of heptachlor epoxide were not significantly different between stations.

Chlordane—1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7methano-1H- i-n-dene

Chlordane is a complex mixture of several cyclopentadiene-derived compounds. Major constituents of chlordane include cis-chlordane, trans-chlordane, cis-nonachlor, and trans-nonachlor. Samples were analyzed for each of these four constituents and the metabolite oxychlordane. In this report, "total chlordane" is the sum of these four major constituents, and the metabolite oxychlordane. Along with testing for these five components individually, a standard of technical chlordane, which contains all constituents, was also used in the laboratory analysis and is reported as chlordane.

Chlordane was detected at nine of the ten sites while "total chlordane" was found at all ten sites. Station 7, Bellevue, had the highest mean wet-weight concentration of both chlordane and "total chlordane", 0.363 mg/kg and 0.1156 mg/kg, respectively (Table II). The mean wet-weight concentration of chlordane at Station 7 exceeded the FDA action level (0.3 mg/kg). Station 7 is immediately downstream

Table II. Mean wet-weight concentration (mg/kg) and (highest concentration) (mg/kg) of chlordane detected in channel catfish (*Ictalurus punctatus*) of the Missouri River, 1988.

Station	Chlordane	cis-Chlordane	trans-Chlordane	cis-Nonachlor	trans-Nonachlor	Oxy-chlordane	Total Chlordane
1	ND	ND	ND	ND	0.006 (0.02)	ND	0.006 (0.02)
2	0.048 (0.094)	0.0023 (0.0035)	0.0027 (0.0047)	0.0031 (0.0066)	0.0038 (0.0099)	0.0022 (0.0026)	0.0142 (0.0288)
3	0.018 (0.050)	0.0014 (0.0024)	0.0018 (0.0038)	0.0008 (0.0025)	0.003 (0.0061)	ND (0.0148)	0.0059
4	0.056 (0.069)	0.0043 (0.0056)	0.0037 (0.0045)	0.0034 (0.0037)	0.0078 (0.0095)	0.0015 (0.0023)	0.0217 (0.0254)
5	0.129 (0.220)	0.007 (0.013)	0.0068 (0.0100)	0.0051 (0.0110)	0.0150 (0.0250)	0.0078 (0.0140)	0.0419 (0.073)
6	0.13 (0.17)	0.0125 (0.0160)	0.0308 (0.0730)	0.0065 (0.0079)	0.0163 (0.0200)	0.0046 (0.0053)	0.0866 (0.1539)
7	0.363 (0.47)	0.044 (0.0590)	0.0283 (0.0370)	0.0100 (0.0120)	0.0277 (0.0350)	0.0051 (0.0067)	0.1156 (0.1434)
8	0.107 (0.110)	0.0085 (0.0089)	0.0095 (0.0120)	0.0056 (0.0063)	0.0127 (0.0140)	0.0017 (0.0028)	0.0380 (0.0393)
9	0.183 (0.220)	0.0163 (0.0210)	0.0127 (0.0160)	0.0127 (0.0140)	0.0230 (0.029)	0.0056 (0.0078)	0.0703 (0.0878)
10	0.075 (0.140)	0.0058 (0.0120)	0.0076 (0.0110)	0.0047 (0.0072)	0.0114 (0.0160)	0.0018 (0.0054)	0.0314 (0.0516)

ND - Not detected in any sample.

from the cities of Omaha, Nebraska and Council Bluffs, Iowa. Since chlordane has been used in the treatment of termites, urban runoff may a be source of chlordane in the fish flesh.

Mean wet-weight concentrations of chlordane, "total chlordane", cis-chlordane, cis-nonachlor, and trans-nonachlor were significantly different among sampling stations ($p < 0.05$). In general, Station 7 was found to be significantly different from the other stations ($p < 0.05$).

Trifluralin—2,6-Dinitro-N,N-dipropyl-4-(trifluoromethyl)benzamine

Trifluralin was detected at all stations except Station 1. Mean wet-weight concentrations were significantly different between stations ($p < 0.05$). The highest wet-weight concentration of trifluralin occurred at Station 7, Bellevue. The LSM test indicated Station 7 was significantly different from all other stations ($p < 0.05$) and Stations 4, 5, 8, 9, 10 were different from Stations 1, 2, 3, and 6.

DISCUSSION

The mean wet-weight concentration of chlordane at Station 7, Bellevue, Nebraska, exceeded the FDA action-level, suggesting channel catfish caught in this area and consumed present a threat to human health. Additional catfish samples were collected in the vicinity of Station 7 during 1989. This additional sampling will help determine if there is a human health risk associated with the consumption of catfish. Sampling should be expanded to in-

clude other recreationally or commercially important species of fish. If additional sampling finds concentrations of chlordane exceeding the FDA action level, a public-health advisory should be issued for the Bellevue area.

Mean wet-weight concentrations of DDT, chlordane, "total chlordane", cis-chlordane, trans-nonachlor, cis-nonachlor, and trifluralin were found to be significantly different between sampling stations. Differences that might be due to higher concentrations of lipid among fish were removed by using an analysis of covariance. The cause(s) of these differences among stations is unknown, but urban runoff is suspected at Station 7.

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